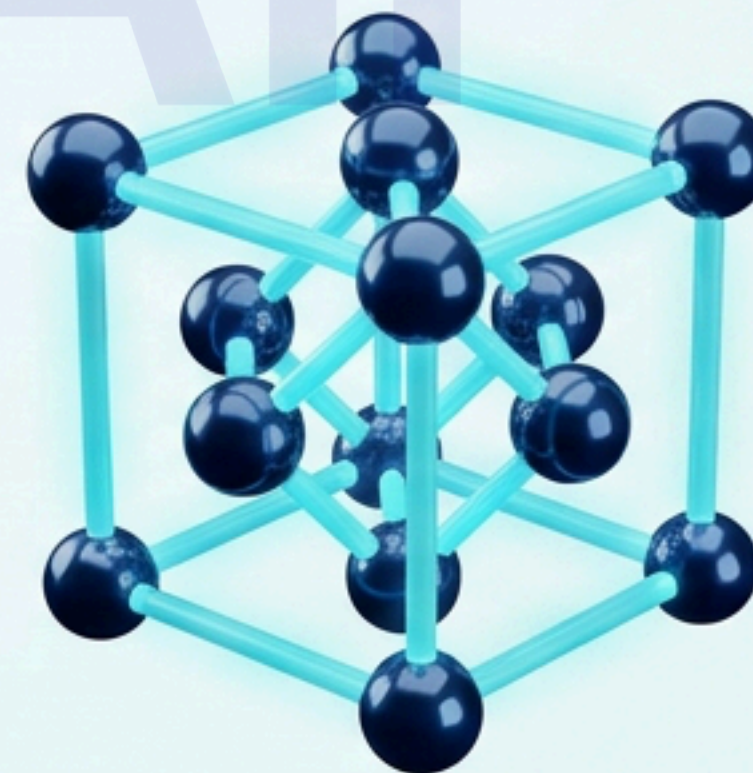


Physical Properties of Transition Metals

Macro observations, atomic mechanisms, and periodic trends of the d-block elements.



The Baseline Metallic Profile



The Exceptions

Zn

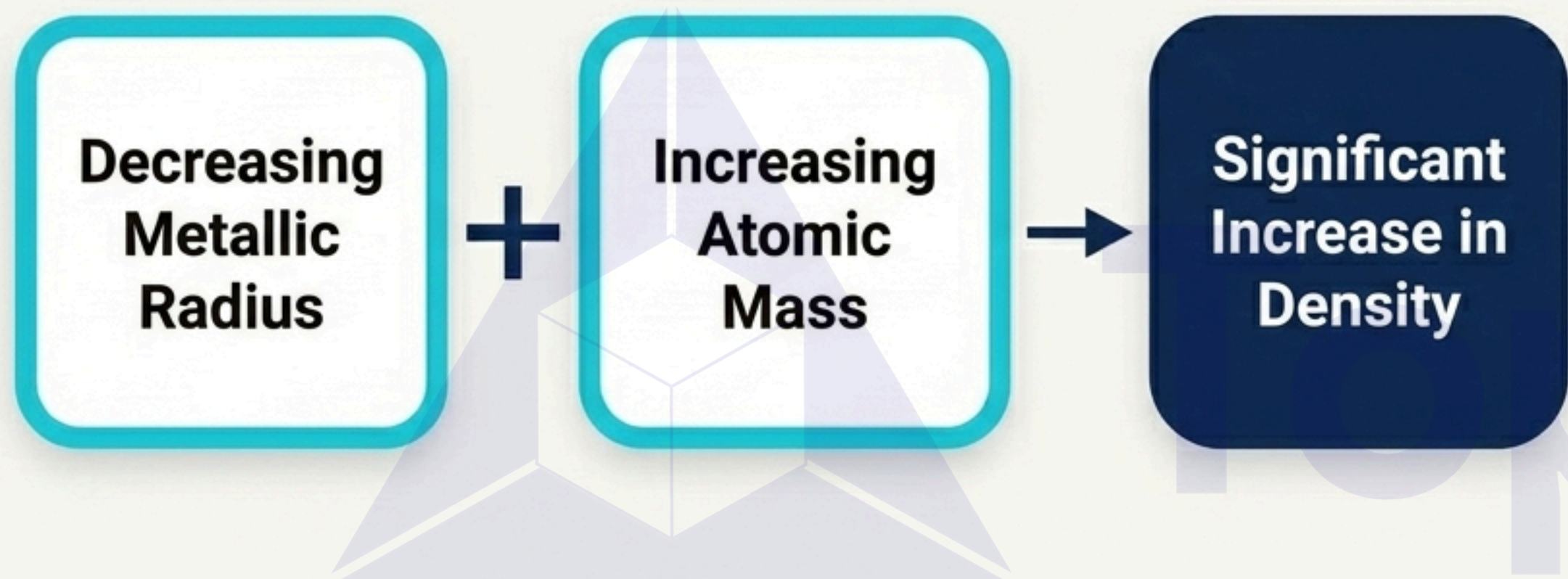
Cd

Hg

Mn

With the exception of these four, transition elements have one or more typical metallic structures at normal temperatures.

Hardness, Volatility, and Density



Key Fact: Transition metals (except Zn, Cd, Hg) are very hard and possess low volatility.

Element	Density (g/cm ³)
Ti	4.1
V	6.07
Cr	7.19
Mn	7.21
Fe	7.8
Co	8.7
Ni	8.9
Cu	8.9



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$$E=mc^2$$



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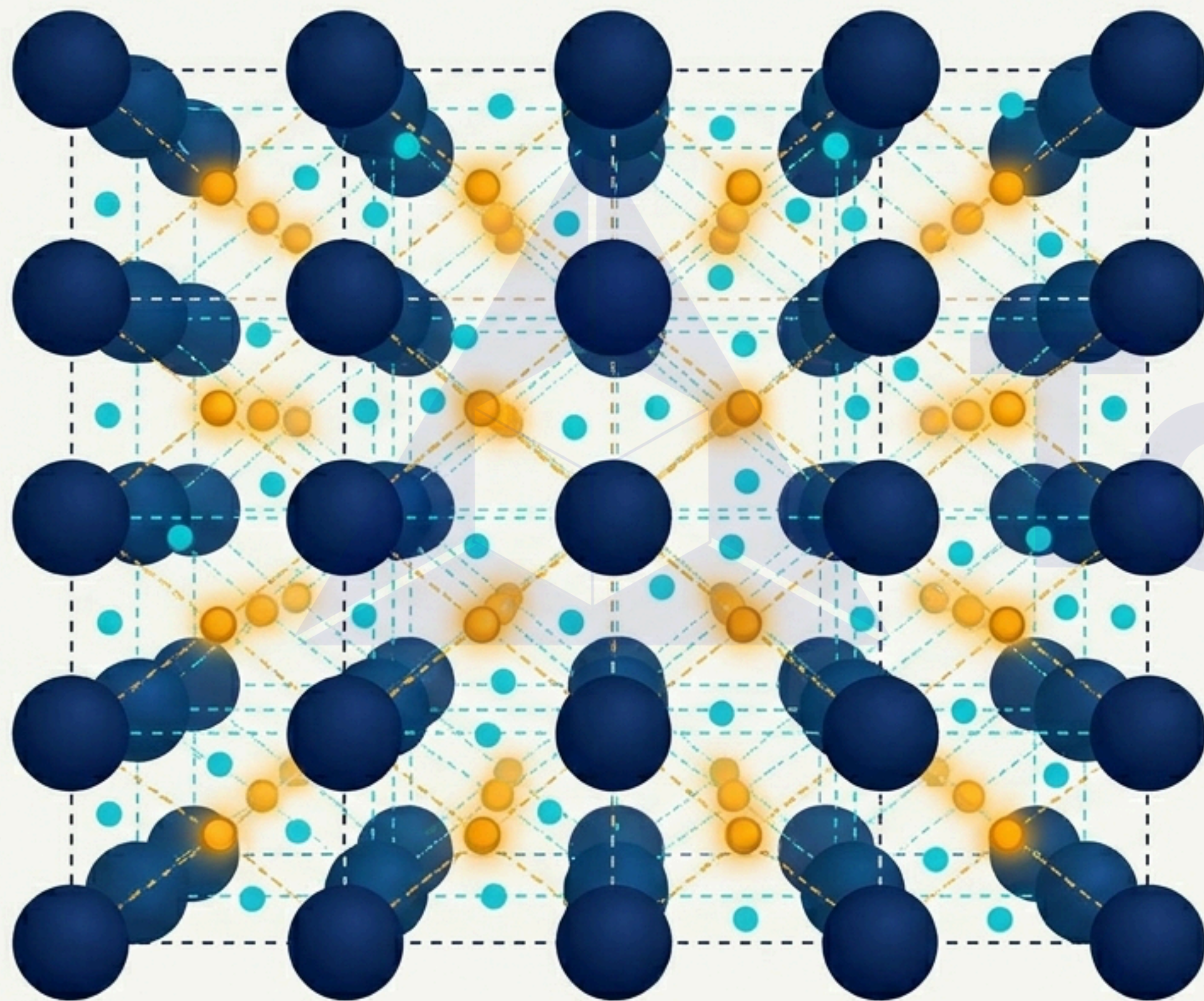
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Key Highlights

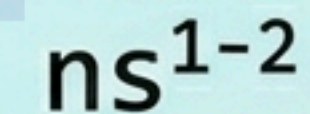
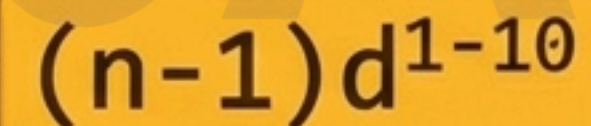
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The Engine of High Melting Points

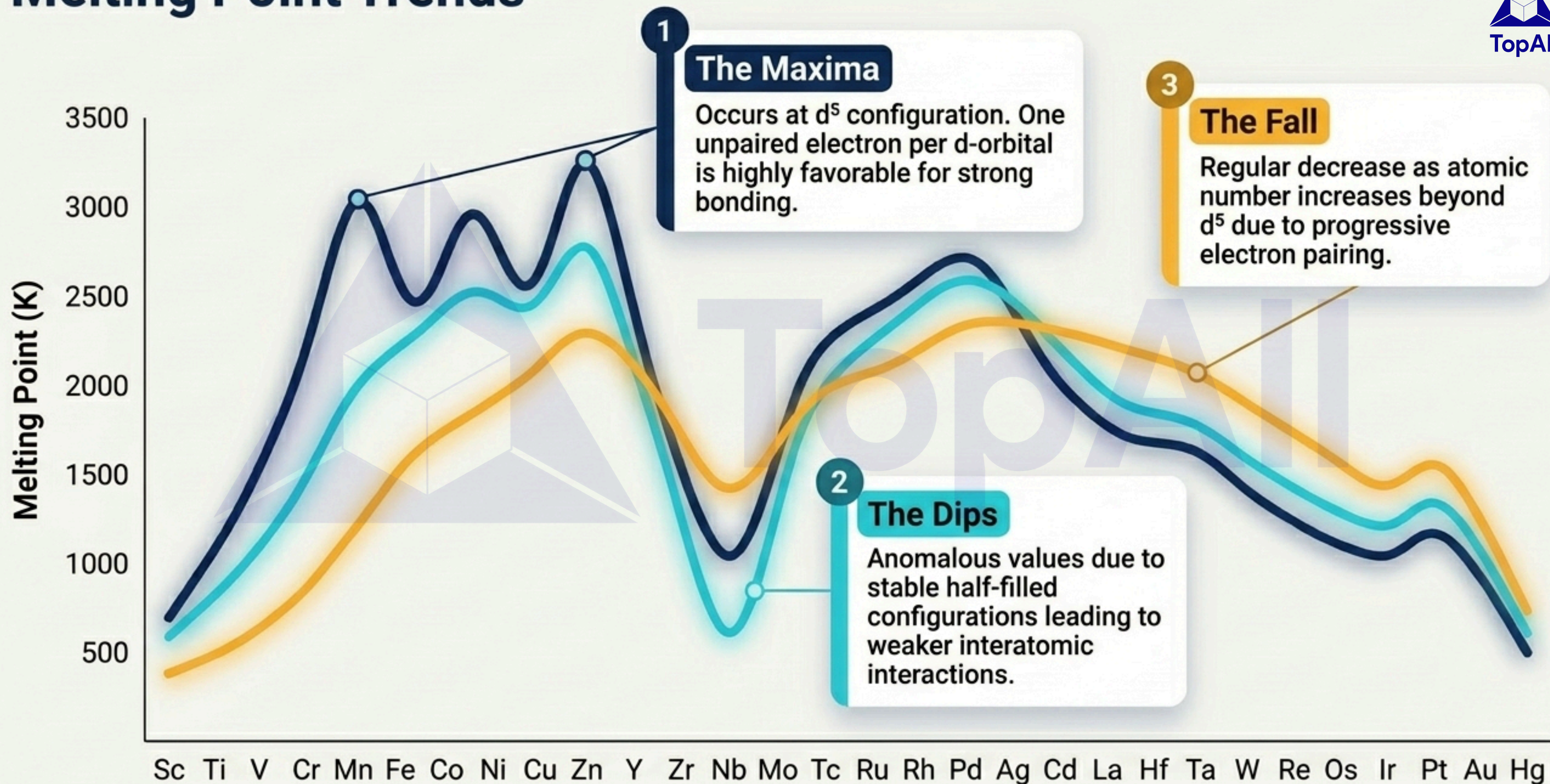


High melting and boiling points are attributed to the involvement of a greater number of electrons from the inner d-orbital in addition to outer s-electrons in the interatomic metallic bonding.



Takeaway: More unpaired electrons = Stronger interatomic interaction.

Melting Point Trends



Enthalpy of Atomisation ($\Delta_a H^\circ$)

Large
number of
unpaired
electrons

Stronger
interatomic
interaction

Stronger
interatomic
metallic
bonding

Higher
Enthalpy of
Atomisation

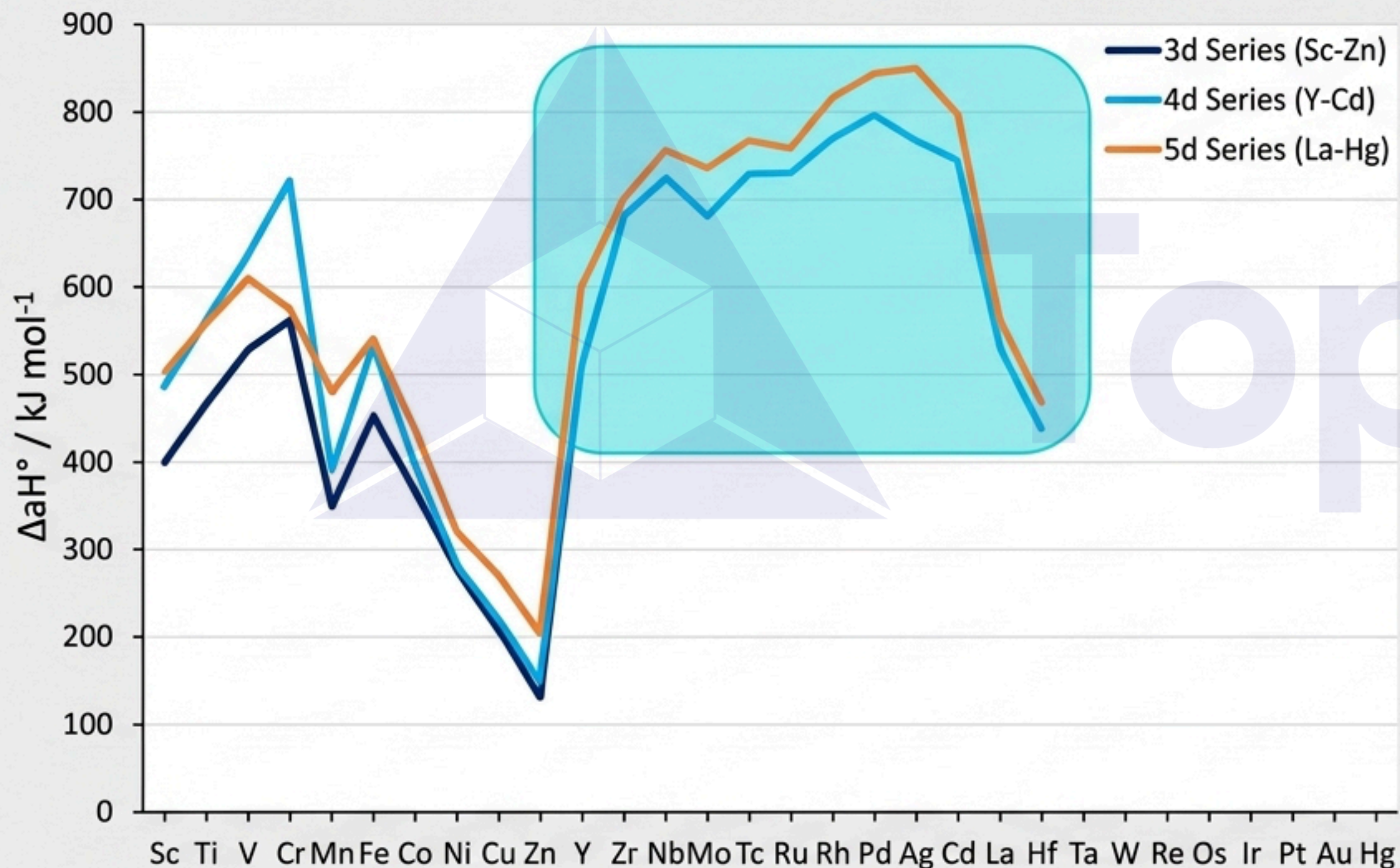


Exam Insight: Noble Character

Metals with very high enthalpy of atomisation (and consequently very high boiling points) tend to be noble in their reactions. Their atomic lattice is **incredibly difficult to break apart.**

Enthalpy Trends & Metal-Metal Bonding

Enthalpies of Atomisation ($\Delta_a H^\circ$)



Observation

Metals of the 2nd (4d) and 3rd (5d) series have significantly greater enthalpies of atomisation than the corresponding elements of the 1st (3d) series.

Chemical Consequence

This massive difference in enthalpy accounts for the occurrence of much more frequent metal-metal bonding in compounds of heavy transition metals.

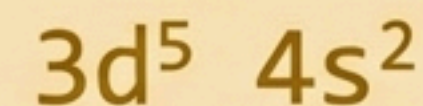
The Anomalies Matrix

Group 12 (Zn, Cd, Hg)



- Subshells are completely filled; zero unpaired electrons.
- Lowest enthalpy of atomisation (e.g., Zn = 126 kJ/mol).
- Macroscopic result: Soft metals, low melting points, highly volatile.

Group 7 (Mn)



- Possesses maximum number of unpaired electrons.
- Despite this, exhibits an anomalous, sharp dip in melting point.
- Macroscopic result: Lower MP due to a complex, less optimal metallic lattice structure that prevents strong effective bonding.

Exam Summary: Physical Properties



The Rule

Melting Point, Boiling Point, and Enthalpy of Atomisation directly scale with the number of unpaired $(n-1)d$ electrons. Bonding strength maximizes at the d^5 configuration.

The Exception

Zinc (Zn), Cadmium (Cd), and Mercury (Hg) are not considered true transition metals because they possess **fully filled d^{10} subshells** in both their ground and stable oxidation states.

The Trap

Do not assume 1st series (3d) metals form the strongest bonds. **Heavier transition metals (4d, 5d) actually have higher enthalpies of atomisation and form metal-metal bonds much more frequently.**



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